Fishery Data Series No. 05-60

Stock Assessment of Sockeye and Coho Salmon from Billy's Hole, Prince William Sound, Alaska, 2003-2004

Final Report for Study FIS 03-033
USFWS Office of Subsistence Management
Fisheries Information Services Division

by

Jan P. Bullock

and

Matt G. Miller

November 2005

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

FISHERY DATA REPORT NO. 05-60

STOCK ASSESSMENT OF SOCKEYE AND COHO SALMON FROM BILLY'S HOLE, PRINCE WILLIAM SOUND, ALASKA, 2003-2004

by
Jan P. Bullock
and
Matt G. Miller
Division of Sport Fish, Anchorage

Alaska Department of Fish and Game
Division of Sport Fish, Research and Technical Services
333 Raspberry Road, Anchorage, Alaska 99518-1599

November 2005

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Jan P. Bullock
and
Matt G. Miller
Alaska Department of Fish and Game, Division of Sport Fish
333 Raspberry Road, Anchorage, AK 99518-1599, USA

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FINAL REPORT SUMMARY PAGE

Title: Stock assessment of sockeye and coho salmon from Billy's Hole, Prince William Sound, Alaska, 2003-2004.

Study Number: FIS 03-033

Investigator(s)/Affiliation(s): Jan P. Bullock and Matt G. Miller, Alaska Department of Fish and Game, Division of Sport Fish, 333 Raspberry Road, Anchorage, AK, 99518, USA.

Patty Brown-Schwalenberg, Chugach Regional Resources Commission, 4201 Tudor Center Drive, Suite 300, Anchorage, AK, 99508, USA.

Management Region: Gulf of Alaska/Cook Inlet Region

Information Type: Stock Status and Trends

Issue Addressed: Data collected from the project will be used for management of subsistence and sport fisheries, and to assess escapements and runs of the sockeye and coho salmon stocks.

Study Cost: $273,100

Study Duration: June 1, 2003–October 31, 2005

Key Words: Billy's Hole, Long Bay, Prince William Sound, sockeye salmon, *Oncorhynchus nerka*, coho salmon, *Oncorhynchus kisutch*, weir, subsistence user, recreational angler, age composition.

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ABSTRACT

A weir was operated at Billy's Hole, part of Long Bay in Prince William Sound, Alaska, during June 14-September 13, 2003 and June 12-September 10, 2004. Fish were counted and sampled as they passed through the weir. Recreational and subsistence users were interviewed concerning their demographics, fishing effort and harvest.

A total of 1,164 sockeye salmon *Oncorhynchus nerka* and 113 coho salmon *O. kisutch* were counted in 2003. Ninety-eight percent of the sockeye salmon in the escapement were age 1.3. Fifty percent of the coho salmon were age 1.1 and the rest were 2.1. Twelve recreational anglers were interviewed. No subsistence users were interviewed or observed in 2003. Ten salmon were sampled from the recreational harvest. All were sockeye aged 1.3. Stream temperatures and water levels were recorded daily.

In 2004, 985 sockeye salmon and 135 coho salmon were counted as they passed through the weir. Of those, 56% of the sockeye salmon escapements were age 1.3, 35% were age 1.2, 5% were age 2.3, 2% were age 2.2, 1% were age 1.4, 0.5% were age 2.1 and 0.5% were age 0.3. Of the 128 coho salmon aged in 2004, 58% were age 1.1, 41% were age 2.1 and 1% were age 3.1. Two groups of subsistence users and 11 groups of recreational anglers were interviewed. One sockeye was aged from the subsistence harvest (age 1.3) and 29 sockeye were aged from the recreational harvest. Forty-eight percent of those fish were age 1.2, 38% were age 1.3, and 14% were age 2.2. Stream temperatures and water levels were recorded daily. Limnological sampling of Billy's and Gull lakes was also conducted in 2003 and 2004.

Key words: Billy's Hole, Long Bay, Prince William Sound, sockeye salmon, *Oncorhynchus nerka*, coho salmon, *Oncorhynchus kisutch*, weir, subsistence user, recreational angler, age composition.

INTRODUCTION

Various user groups harvest sockeye *Oncorhynchus nerka* and coho *O. kisutch* salmon throughout Prince William Sound (PWS). Accurate data concerning escapement and harvest of these stocks is important to manage for sustainable salmon returns, but little is known about effort, catch and harvest by non-commercial users. The Glacier Ranger District of the United States Forest Service (USFS) and local residents of Tatitlek and Chenega Bay identified several sites with subsistence salmon fisheries in western Prince William Sound as potential sites for collecting information about escapement and subsistence use. Billy's Hole was chosen for study because of its small run size and potential high utilization by rural subsistence fishers from the communities of Tatitlek and Chenega Bay. In addition, these sockeye salmon are valued by anglers from the city of Valdez because this is one of only a few sport fisheries for sockeye salmon accessible to anglers in northern Prince William Sound.

Recreational fishers and subsistence users target the Billy's Hole area primarily for the harvest of sockeye salmon. Billy's Hole is located 33 miles southwest of Valdez and 22 miles northwest of Tatitlek in the southwest area of Long Bay at approximately 60º 58' N latitude and 147º 17' W longitude. The system consists of an 83-acre upper lake narrowing to a 25-acre lower shallow lake. The lower lake has two active outlets, both containing waterfalls at tidewater, and a dry outlet that overflows during high water. All three outlets flow into a saltwater lagoon accessible by two narrow saltwater passages from Long Bay (Figures 1 and 2).

Aerial surveys of Billy's Hole by ADF&G Commercial Fisheries Division from 1963 through 2003 provided indices of salmon escapement (Appendix A). Based on peak indices, 500-2,500 sockeye salmon would be expected to return to this system. Sample sizes from the Statewide Harvest Survey, a household mail survey of licensed anglers, were insufficient to reliably estimate effort, harvest and catch at Billy's Hole from 1996-1999 (Howe et al. *a-d*). Subsistence users in this area are required to have a permit to fish and to record catch and harvest data, but ADF&G records for several years show that very few permits have been returned and some did not have harvest recorded. Therefore, for managers to make sound decisions regarding the

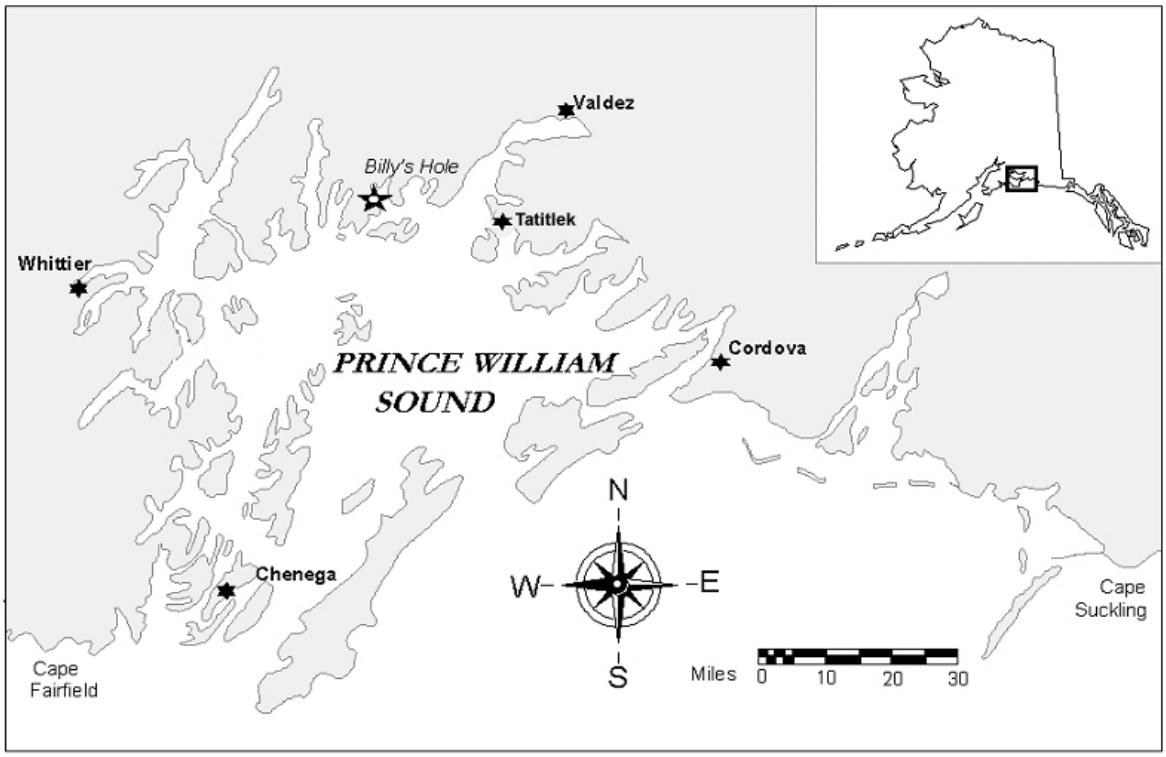

Figure 1.-Prince William Sound showing the location of Billy's Hole.

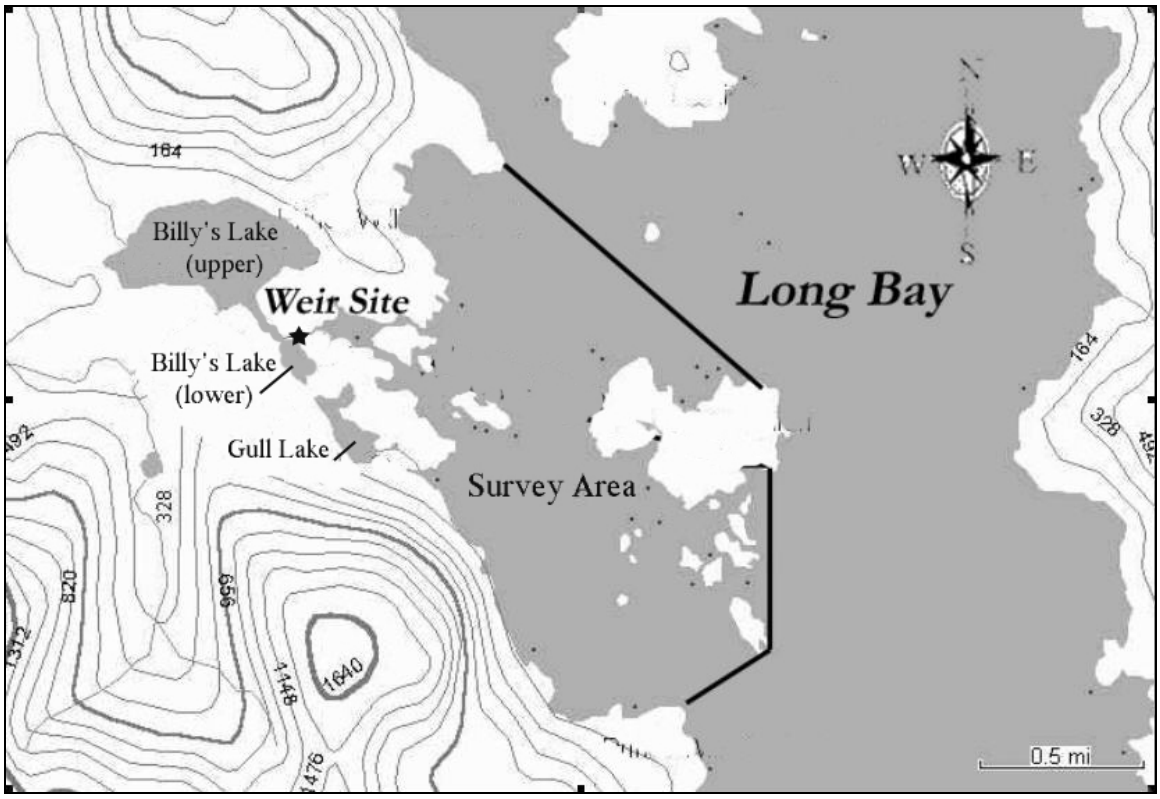

Figure 2.-Billy's Hole and the study area.

salmon resources at this site, this 2-year study was designed to estimate the annual harvest and effort of sockeye and coho salmon by subsistence users and recreational anglers, census escapement through a weir, and estimate sex, age and length composition of returning salmon.

OBJECTIVES

The objectives of this study of sockeye and coho salmon at Billy's Hole were to:

1. Census the sockeye and coho salmon escapement into Billy's Lake from June 15 to September 24, 2003 and 2004.
2. Estimate the age, sex and length composition of the salmon escapement into Billy's Lake from June 15 to September 24, 2003 and 2004.
3. Estimate the age, sex and length composition of the recreational and subsistence harvest of salmon at Billy's Hole from June 15 to September 24, 2003 and 2004.
4. Estimate the effort and harvest of subsistence users at Billy's Hole from June 15 to September 24, 2003 and 2004.
5. Estimate the effort and harvest of recreational anglers at Billy's Hole from June 15 to September 24, 2003 and 2004.
6. Summarize the proportion of fishing effort by user group (recreational or subsistence); fishing trip duration; terminal tackle type (flies, bait, lures, nets); and angler type (resident/nonresident, guided/unguided) at Billy's Hole from June 15 to September 24, 2003 and 2004.

METHODS

ESCAPEMENT

Sockeye and coho salmon were counted as they passed through a stationary picket weir and upstream trap at the northern outlet of Billy's Lake from June 15-September 13, 2003, and June 12-September 10, 2004. The distance between pickets was 13 mm, which effectively blocked all fish species but small Dolly Varden *Salvelinus malma*. Modifications were made to the weir in 2004 to stabilize it and keep it intact in the event of high water. These modifications included a 5/16 inch steel cable that passed behind the weir and was anchored to large trees on both sides of Billy's Creek and the addition of another leg to each of the four tripods that supported the weir.

Daily counts and fork length measurements of sockeye and coho salmon were entered on salmon weir count forms and transferred to ADF&G standard age-weight-length mark-sense forms (Version 1.2). Pink *O. gorbuscha* and chum salmon *O. keta* and Dolly Varden were also counted. The proportion by age and sex of the sockeye and coho salmon in the escapement was estimated as follows:

$$\hat{p}_z = \frac{n_z}{n}, \tag{1}$$

where: $\hat{p}_z$ equals the estimated proportion of the sockeye or coho salmon passing the weir from age and sex category z, n_z equals the number of fish sampled that were classified as age and sex category z, and n equals the number of sockeye or coho salmon sampled for age and sex determination.

The variance of $\hat{p}_z$ was calculated by:

$$\hat{V}[\hat{p}_z] = \left(1 - \frac{n}{N}\right) \frac{\hat{p}_z(1-\hat{p}_z)}{n-1}, \quad (2)$$

where N is the number of sockeye or coho salmon passing the weir.

The estimates of escapement by age and sex category *z* were calculated by expansion of $\hat{p}_z$ by the escapement (i.e. *N*), as follows:

$$\hat{N}_z = N\hat{p}_z, \quad (3)$$

with variance estimated as:

$$\hat{V}[\hat{N}_z] = N^2 \hat{V}[\hat{p}_z]. \quad (4)$$

Standard errors were calculated as the square root of the variances.

Water level and stream temperature were measured daily. A graduated staff gauge was fastened to a tree on the stream bank and relative stream levels were recorded twice daily. An *Onset Water Temp Pro Logger*[1] electronic temperature recorder was fastened to the weir below the water line and set to measure stream temperature every hour. In addition, technicians recorded stream temperatures with a hand-held thermometer twice daily.

CREEL SURVEY

2003

A roving-roving creel survey (Pollock et al. 1994) was used in 2003 to estimate the daily effort by recreational and subsistence users, and to estimate the salmon harvest of these two user groups. This survey design allowed technicians to rove through the fishery counting anglers and to rove among anglers to collect effort and harvest data. The survey was temporally stratified into two intervals: June 15-August 15 and August 16-September 13. The design consisted of a two-stage survey (Cochran 1977) in which in the first stage days were sampled systematically (every other day) starting June 16. The second stage consisted of angler counts for effort estimates and angler interviews for harvest estimates. Angler counts were used to estimate fishing effort in units of angler-hours. Angler interviews, conducted during the time not used for angler counts, were conducted just prior to or just after angler counts. Interviews included collecting information on catch, harvest, user group (recreational or subsistence), trip type (guided or unguided), terminal tackle (lure, fly, net), and angler residency. The census of angler catch, effort and harvest in 2003 was also summarized.

2004

In 2004, we again used a roving-roving creel survey, but because of low angler effort in 2003 modified the design to include sampling every day to attempt to increase the sample size of anglers. In addition, technicians attempted to count and interview every angler that entered the study area and to keep a record of angler catch, effort, boat size, boat name and number of people fishing. The count schedule in 2004 was modified to include three 15-minute count periods per day starting on June 15 and ending on September 24 or whenever the weir counts

[1] Product names used in this report are included for scientific completeness, but do not constitute a product endorsement.

were finished for the season. Species, sex and length data were collected from harvested salmon and scales were collected for aging (see procedures below).

Angler counts were recorded on Sport Fish Division angler count mark-sense forms, version 1.2. Angler interviews were recorded on angler interview mark-sense short forms, version 1.0. Biological data were recorded on age-weight-length mark-sense forms, version 1.2. A summary of subsistence and recreational angler interviews and catch data in 2004 was also generated.

AGE, SEX, AND LENGTH SAMPLING

In 2003 and 2004, biological data were collected from sockeye salmon at the Billy's Hole weir sampling box during each of three temporal strata: June 15–July 10, July 11-25, and July 26-August 31. Sampling was conducted daily. Every tenth fish entering the trap was sampled in June and July of 2003. Due to lower than expected fish passage occurring in those months, we modified our sampling in July, August and September 2004 to include every fifth sockeye and every coho that passed the weir. Fish were passed through the trap during the early morning and late evening to allow for their expedited passage upstream.

Sampled fish were measured from mid-eye to fork-of-tail and sex determined. One scale was taken from each sockeye and three from each coho and mounted on gum cards. Scales were taken from the left side of the body, at a point on a diagonal line from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin, two rows above the lateral line. Scales were taken proximal to the preferred region when necessary, although only within the area bounded dorsally by the fourth row of scales above the lateral line, ventrally by the lateral line, and between lines drawn vertically from the posterior insertion of the dorsal fin and the anterior insertion of the anal fin. (Clutter and Whitesel 1956; Scarnecchia 1979). If scales were not available in the preferred region on the left side of the fish, scales were collected from the preferred region on the right side. The recreational and subsistence harvested salmon were also sampled for age, sex, and length. Age was interpreted at the Cordova AWL (age, weight, length) lab from the scales. Age and sex composition was summarized in 2004.

LAKE AND STREAM CHARACTERISTICS

Streams feeding Billy's Lake, and neighboring Gull Lake, were monitored for fish presence. Sockeye spawning habitat along the lake margins was identified through fish counts, stream walks and lake surveys.

In 2004, measurements of lake depth, temperature, dissolved oxygen and clarity were taken following procedures in Koenings et al. (1986) at Billy's Lake and Gull Lake, a 25 acre lake just southeast of Billy's Lake (Figure 3). Measurements of pH, conductivity, and turbidity were also taken at Billy's Lake. Two plankton trawls were conducted on June 28 and August 7, 2004, at the deepest point of Billy's Lake.

RESULTS

ESCAPEMENT

2003

In 2003, the weir was in place from June 15-September 13, and was operational for 86 of those 91 days. It was not operational from August 14-17 and on August 26 due to flooding which may have allowed uncounted escapement.

Figure 3.-Aerial photo of Billy's Hole and study area.

A total of 1,164 sockeye were counted and passed upstream through the weir. The first sockeye was passed on June 15 and the last on August 29 (Table 1). The highest daily count of 156 sockeye occurred on July 17. The midpoint of the run occurred on July 15 when 52% of the sockeye had passed through the weir (Table 1, Figure 4).

A total of 113 coho salmon were counted and passed upstream through the weir. The first coho salmon was counted on July 30 and the last on September 13 (Table 1). The highest daily count of 16 coho occurred on August 20, which was also the midpoint of the run (Table 1, Figure 5).

Counts of other fish species passing through the weir in 2003 included 272 chum salmon; 3,840 pink salmon and 1,815 Dolly Varden (Table 1).

2004

In 2004, the weir was in place from June 12-September 10. It was operational for 87 of those 91 days, and was non-operational on June 17 and 18, July 27 and August 27 due to high water, which may have allowed uncounted escapement. A total of 985 sockeye salmon were counted as they passed through the weir. The first sockeye was passed on June 29 and the last on September 6 (Table 1). The highest daily count of 152 sockeye occurred on July 13, which was also the midpoint (Table 1, Figure 4).

A total of 135 coho salmon were counted as they passed through the weir. The first coho was counted on July 23 and the last on September 6 (Table 1). The highest daily count of 34 coho was on August 28, which was also the midpoint (Table 1, Figure 5).

Other fish species passing the weir included 49 chum salmon; 2,555 pink salmon and 6,188 Dolly Varden (Table 1).

Table 1.-Run timing and numbers of fish passing Billy's Hole weir in 2003 and 2004.

	Sockeye	Chum	Pink	Dolly Varden	Coho
2003					
Start	15-Jun	2-Jul	15-Jul	19-Jun	30-Jul
End	29-Aug	21-Aug	9-Sep	29-Aug	13-Sep
Midpoint	15-Jul	12-Jul	22-Aug	20-Aug	20-Aug
Number of Run Days	76	50	57	72	46
Total Number of Fish	1,164	272	3,840	1,815 [a]	113
2004					
Start	29-Jun	4-Jul	19-Jun	23-Jul	23-Jul
End	6-Sep	16-Aug	29-Aug	6-Sep	6-Sep
Midpoint	13-Jul	20-Jul	9-Jul	28-Aug	28-Aug
Number of Run Days	70	44	72	46	46
Total Number of Fish	985	49	2,555	6,188 [a]	135

[a] This is a minimum as some Dolly Varden escaped through the weir undetected.

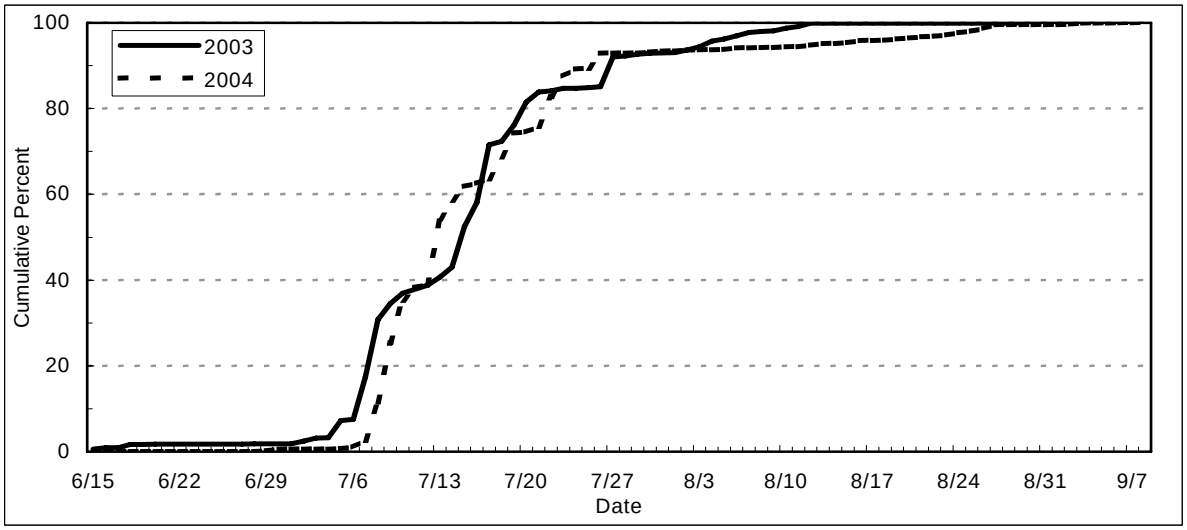

Figure 4.-Comparison of run timing for sockeye salmon at the Billy's Hole weir, 2003 and 2004.

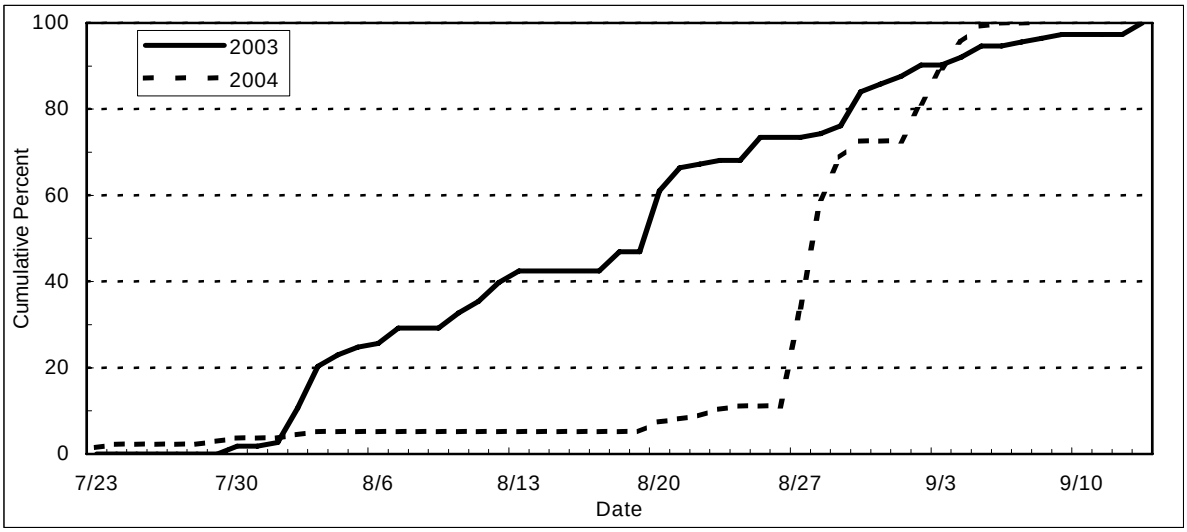

Figure 5.-Comparison of run timing for coho salmon at the Billy's Hole weir, 2003 and 2004.

CREEL SURVEY

2003

In 2003, no estimates of angler effort, catch or harvest were made because of the small sample size. Only 12 recreational anglers were interviewed during 2003 because of the limited time periods and when these time periods occurred (Table 2). No subsistence users were observed during the 2003 study. Some anglers arrived and departed at night when crews were sleeping. Other anglers fished outside of the study area. A few anglers left when they were approached for interviews.

2004

In 2004, no estimates of angler effort, catch or harvest were made because of the small sample size. Interviews were conducted within the established creel sample times with nine recreational angler groups (Table 3). All of the recreational anglers used rod-and-reel rigged with lures or snagging treble hooks. Fifteen of the recreational anglers were Alaskan residents and three were non-residents. Fish harvested included sockeye, chum and pink salmon, Dolly Varden and Pacific halibut *Hippoglossus stenolepis*.

Two subsistence groups were interviewed within the established creel sample times, consisting of five residents (one group of three, one group of two) from the village of Tatitlek. Both groups used gillnets and targeted sockeye salmon. They fished several hours and harvested at least 20 sockeye (Table 3).

Some interviews were conducted before anglers finished fishing and some interview forms were not filled out completely but included useful information about angler effort and harvest. This additional information is presented in Appendix C. As in 2003, some anglers arrived or departed during the night, avoided the fishery once they saw camp, or motored away when approached for an interview.

Table 2.-Summary of recreational angler interviews at Billy's Hole, 2003.

				Fish				
Date	Fishing Period	Angler Number	Hours Fishing	Species	Number Caught	Number Released	Sex	Length (mm)
7/2/2003	3	1	3	Sockeye	4	0	F	595
				Sockeye			F	575
				Sockeye			M	605
				Sockeye			F	565
7/2/2003	3	2	3	Sockeye	4	0	F	540
				Sockeye			F	580
				Sockeye			F	582
				Sockeye			M	613
7/6/2003	2	1	2					
7/8/2003	2	1	3	Dolly Varden	1			
		2	3	Dolly Varden	1			
7/12/2003	3	1	3	Chum	3	3		
7/18/2003	3	1	2	Sockeye	1		F	510
	3	2	2	Sockeye	1		F	545
	3	3	2					
	3	4	2					
	3	5	2					
	3	6	2					

AGE, SEX AND LENGTH COMPOSITIONS

2003

In 2003, age, sex and length data were available for 64 sockeye salmon in the escapement. Of these, 42% were female and 58% were male. Most (98%) were aged 1.3 and the remaining fish were aged 2.3 (Table 4). Mean length of females in the escapement was 560 mm and mean length of males was 596 mm. Ten sockeye were sampled from the recreational harvest and all were aged 1.3.

Age, sex and length data were available from 30 coho salmon in the escapement. Of those, 63% were female and 37% were male. Fifty percent of the coho were aged 1.1 and 50% were aged 2.1 (Table 5). Mean length for females was 582 mm and for males was 581 mm.

2004

In 2004, age, sex and length data were available for 195 sockeye salmon in the escapement. Three brood years and seven age classes were identified. Most sockeye salmon in the escapement were aged 1.2 (35%), or aged 1.3 (56%) (Table 6). The escapement was composed of 38% females and 62% males. Mean length of females was 551 mm and mean length of males was 573 mm.

Table 3.-Summary of subsistence and recreational angler interviews at Billy's Hole, 2004.

Date	Fishery Type[a]	Number Anglers	Resident Non-Res	Hours Fished	Effort (hrs)	Gear used	Species	Number Kept	Number Released
7/1/2004	Rec	2	2Res	2.5	5	Rod/Reel		0	0
7/2/2004	Rec	2	2Res	10	20	Rod/Reel	Sockeye	3	0
							Dolly Varden	0	24
7/7/2004	Rec	3	3Res	5.25	15.8	Rod/Reel	Sockeye	3	0
							Chum	1	6
							Dolly Varden	2	3
7/7/2004	Rec	2	2Res	3	6	Rod/Reel		0	0
7/10/2004	Rec	3	Unknown	2	6	Rod/Reel	Sockeye	6	0
							Dolly Varden	5	0
							Pink	1	1
							Chum	1	1
7/11/2004	Sub	2	2Res	Unknown	Unknown	Gillnet	Sockeye	10	0
7/17/2004	Rec	2	2Res	4	8	Rod/Reel		Unknown	Unknown
7/17/2004	Sub	3	3Res	7	21	Gillnet	Sockeye	10	0
7/23/2004	Rec	7	4Res	2.5	15	Rod/Reel	Sockeye	13	0
			3Non			Rod/Reel	Pink	4	3
7/24/2004	Rec	3	3Res	1.5	4.5	Rod/Reel	Sockeye	11	0
							Pink	0	3
8/7/2004	Rec	5	Unknown	Unknown	Unknown	Rod/Reel	Pink	0	4
Total		34		37.75	101.3			70	45

Notes: All anglers fished from boats; all recreational anglers were unguided; all recreational anglers used lures or snagging treble hooks.

[a] Sub = subsistence; Rec = recreational.

Table 4.-Age and sex composition of the sockeye salmon escapement through Billy's Hole weir, 2003.

Statistic	Age 1.3 (1998)	Age 2.3 (1997)	Total
Female			
Sample size	27	0	27
Percentage of sample	42	0	42
Escapement	491	0	491
Male			
Sample size	36	1	37
Percentage of sample	56	2	58
Escapement	655	18	673
Total			
Sample size	63	1	64
Percentage of sample	98	2	100
Escapement	1,146	18	1,164
SE	18	18	

Notes: Data collected from July 2–August 2, 2003; brood year in parentheses.

Table 5.-Age and sex composition of the coho salmon escapement through Billy's Hole weir, 2003.

Statistic	Age 1.1 (2000)	Age 2.1 (1999)	Total
Female			
Sample size	8	11	19
Percentage of sample	27	37	63
Escapement	30	41	72
Male			
Sample size	7	4	11
Percentage of sample	23	13	37
Escapement	26	15	41
Total			
Sample size	15	15	30
Percentage of sample	50	50	100
Escapement	57	57	113
SE	10	10	

Notes: Data collected from July 30–September 13, 2003; brood year in parentheses.

Table 6.-Age and sex composition of sockeye salmon escapement through the Billy's Hole weir, 2004.

	Brood Year 2000			Brood Year 1999		Brood Year 1998		
Statistic	Age 0.3	Age 1.2	Age 2.1	Age 1.3	Age 2.2	Age 1.4	Age 2.3	Total
Female								
Sample size	0	30	0	37	1	1	5	74
Percentage of sample	0	15	0	19	1	1	3	38
Escapement	0	152	0	187	5	5	25	374
Male								
Sample size	1	39	1	73	2	1	4	121
Percentage of sample	1	20	1	37	1	1	2	62
Escapement	5	197	5	369	10	5	20	611
Total								
Sample size	1	69	1	110	3	2	9	195
Percentage of sample	1	35	1	56	2	1	5	100
Escapement	5	349	5	556	15	10	45	985
SE	5	34	5	35	9	7	15	

Notes: Data collected from June 29–September 6, 2004.

Age, sex, and length data were available for 102 coho salmon from the escapement. Three brood years and three age classes were identified. Most were aged 1.1 (58%) or aged 2.1 (41%) (Table 7). The escapement was composed of 37% females and 63% males. Mean length of females was 604 mm and for males was 613 mm.

LAKE AND STREAM CHARACTERISTICS

Water levels and stream temperatures were variable during both years (Figures 6 and 7). Characteristics of Billy's and Gull lakes are reported in Appendices B1-B4.

OTHER OBSERVATIONS

In 2003, chum and pink salmon and Dolly Varden were observed in Billy's Lake. Dolly Varden were most numerous just off the two stream mouths emptying into the larger upper lake. Pink salmon were seen spawning in both these streams and some coho were observed in the narrows between the upper and lower lakes.

In 2004, chum salmon were seen spawning in one stream that enters into the larger upper lake and a slough area in that vicinity. Sockeye were seen spawning along the edge of the larger upper lake also. Coho were mostly observed in the narrows and smaller lower lake, and Dolly Varden were seen occasionally near the two stream mouths that empty into the upper lake. Due to very low rainfall in 2004 as compared to 2003, these two stream mouths as well as the slough area dried up and impeded fish migration (Figure 6). Several sockeye and a few coho were seen schooling in front of the outlet to Gull Lake but were unable to jump the falls due to low or no water. In September 2004, when some rain did fall, sockeye entered Gull Lake and spawned.

Table 7.-Age and sex composition of coho salmon escapement through the Billy's Hole weir, 2004.

Statistic	Age 1.1 (2001)	Age 2.1 (2000)	Age 3.1 (1999)	Total
Female				
Sample size	23	15	0	38
Percentage of sample	23	15	0	37
Escapement	29	19	0	48
Male				
Sample size	36	27	1	64
Percentage of sample	35	26	1	63
Escapement	45	34	1	80
Total				
Sample size	59	42	1	102
Percentage of sample	58	41	1	100
Escapement	74	53	1	128
SE	6	6	1	

Notes: Data collected from July 29–September 6, 2004; brood year in parentheses.

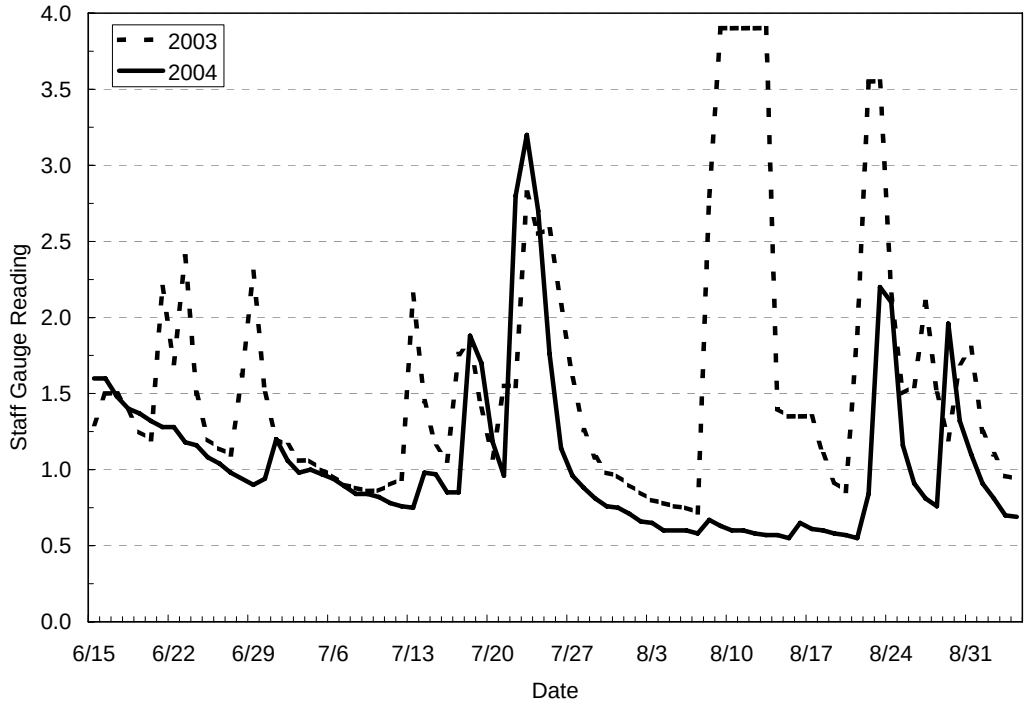

Figure 6.-Water levels at Billy's Hole weir, 2003 and 2004.

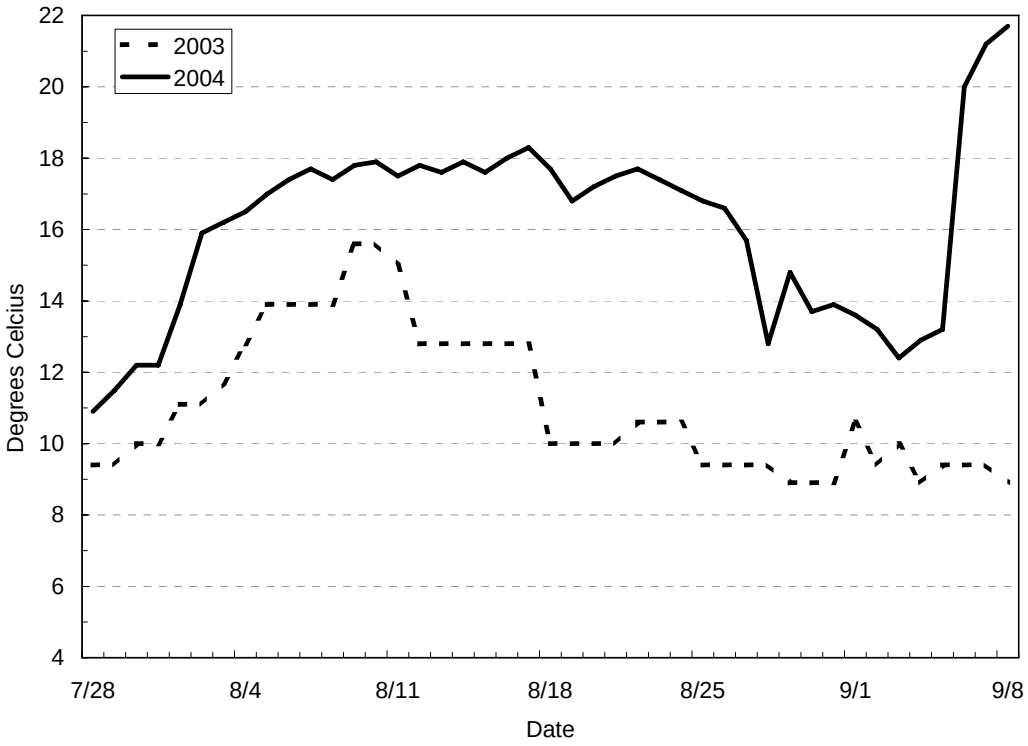

Figure 7.-Stream temperatures at Billy's Hole weir, 2003 and 2004.

DISCUSSION

ESCAPEMENT

Results of this study confirm previous aerial surveys that runs of coho and sockeye salmon to Billy's Hole are small. Harvestable surplus of these stocks is small, and these populations could be easily affected by environmental conditions. A gillnet set at the falls leading to Billy's Lake or to the entrances of the lagoon could harvest a significant number of fish, and possibly lead to decreased returns in the future, or could completely decimate the runs. The small returns of sockeye entering Gull Lake could also be seriously affected by a gillnet set at the outlet falls or by an increase in snagging by anglers. The remoteness of Billy's Hole is not conducive to frequent patrols by Fish and Wildlife Protection Officers. The full time presence of a field camp would be one way to limit illegal harvests while acquiring much needed data on this fishery.

2003

The 2003 escapement of 1,164 sockeye salmon and 113 coho salmon through the Billy's Hole weir was within the expected range given the survey peak counts of 500-2,500 fish during previous aerial surveys (Appendix A). The weir was removed in 2003 before the target removal date of September 24 due to the absence of fish. Water levels recorded throughout the field season in 2003 showed a rapid increase during rainfall in August (Figure 6). The 5 days of high water in August 2003 collapsed the weir and likely allowed fish to pass uncounted. Because this occurred late in the season, it is unlikely that sockeye salmon went uncounted but coho salmon may have, thus biasing the count low for coho salmon. Small Dolly Varden were seen going

through the weir and were at times too numerous to count. After the weir was reinstalled in August 2003, observations of the lake did not indicate that a large number of salmon had escaped upstream during the flood.

2004

The 2004 escapement of 985 sockeye and 135 coho was again within the expected range. In 2004, the weir was removed on September 9 due to lack of fish. Modifications to the weir in 2004 helped alleviate problems during floods by stabilizing it and preventing its collapse during the three floods in June, July and August. Some sockeye and coho salmon may have escaped uncounted over the weir during high water in July and August, thus counts for those species may be low for 2004. However, observations of the lake after these high water events did not indicate that significant numbers of fish had escaped uncounted.

Due to lack of rain and more sunshine, stream temperatures were higher in 2004 than in 2003 (Figure 7) and the feeder streams emptying into Billy's Lake and the stream emptying Gull Lake at salt water went dry (Figure 6). This prevented fish from using the feeder streams to spawn and prevented fish from entering Gull Lake.

A few of the 49 chum salmon did migrate up the Billy's Lake feeder streams before the dry spell in 2004 but could not be located once these streams went dry. Chums were not documented in this system before 2003 when 272 were counted passing through the weir. Otoliths collected opportunistically from chum salmon in Long Bay near Billy's Hole in 2004 showed that some were hatchery strays (Richard Merizon, ADF&G, Cordova, personal communication,). The run timing of chum salmon in 2003 and 2004 does overlap that of the sockeye run timing (Figures 4 and 8). One fish resembling a sockeye and chum cross was taken from the weir in 2004 and preserved for further analysis.

Almost four times the number of Dolly Varden were counted through the weir in 2004 than in 2003. Dolly Varden did not stage at the feeder stream mouths of Billy's Lake in 2004 as they did in 2003, most likely due to low water and the lack of salmon and eggs as food in the streams. Technicians could not determine where the Dolly Varden went in Billy's Lake once they passed the weir. Increased stream and lake temperature and intense sunshine may have forced fish to deeper areas of the lake.

CREEL SURVEY

2003

The small amount of data collected during the creel survey in 2003 may have been due to the full time presence of the weir camp. In the past, anglers have reportedly snagged overlimits of salmon in fresh water. Once the project field camp was established and anglers arrived to see a department presence, word passed among anglers in Valdez that this fishery was being studied (Tchaika Fishing Guide Services, Valdez, personal communication). The established ADF&G field camp near this fishery may have discouraged anglers from fishing, or caused them to avoid the area, resulting in a small sample.

2004

The modified creel census in 2004 resulted in more interviews of recreational anglers, but several were not interviewed because they arrived or left in the middle of the night or left when they were approached for interviews. The presence of the camp and technicians may have

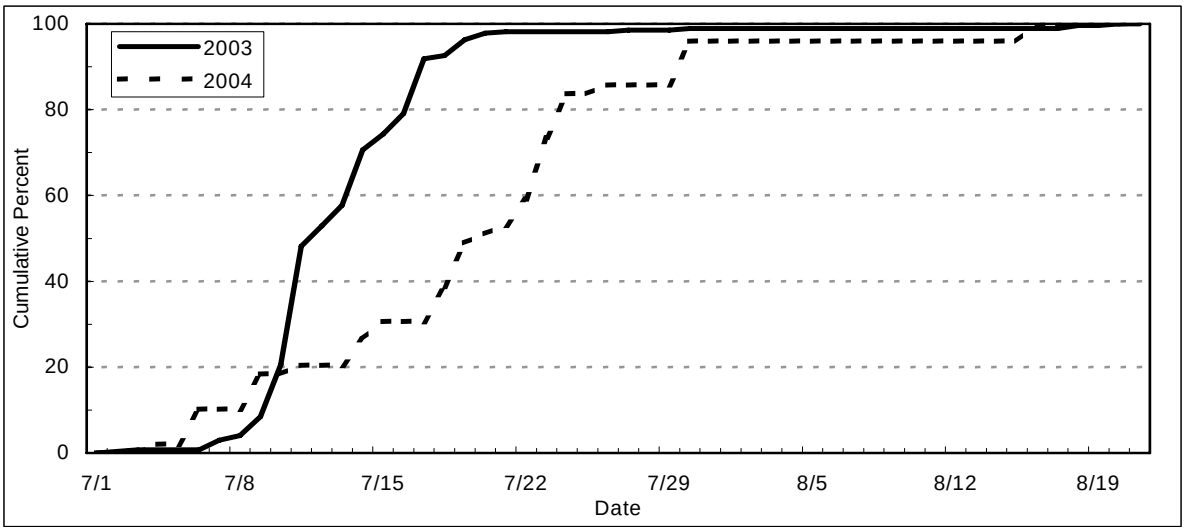

Figure 8.-Comparison of run timing for chum salmon at the Billy's Hole weir, 2003 and 2004.

caused anglers to avoid fishing there. Because only two subsistence groups were interviewed in 2004, little additional information about their use of the area was documented. Boats were seen by the technicians fishing with nets outside of the study area but they were not contacted.

Because of the small size of the fishery, possibly exacerbated by the ADF&G camp, and because some subsistence anglers may have fished outside the study area and thus were not included in the study, the creel survey did not yield reliable estimates of effort, catch and harvest.

LAKE LIMNOLOGY

Lake limnology had not been documented as of 2003 and spawning habitat had not been evaluated to determine how many fish this system could support. The plankton trawls conducted in 2004 yielded very little biomass. A lack of copepods as a source of food for sockeye may be a limiting factor in the number of fish Billy's Lake can support. Cold, deep, clear water and low dissolved oxygen levels may also be limiting factors (Appendices B1 and B3).

The baseline data collected in 2003 and 2004 may be useful in determining how many sockeye this system can support and how this fishery will be managed in the future. A more intense investigation of Gull Lake may yield how this small system is contributing to sockeye abundance at Billy's Hole.

OTHER OBSERVATIONS

A continuation of chum otolith collection, both in Long Bay and in Billy's Hole, would give an indication of the extent of hatchery chum salmon straying and their affect on sockeye of Billy's Hole. A run timing study of chum salmon entering Billy's Lake may show if chums are displacing sockeye on the redds.

A continuation of this study would give a better picture of returns to the system, if the escapements in 2003 and 2004 were characteristic, and if returns fluctuate in a 5-6 year cycle.

Outmigrant surveys could determine if salmon are leaving this system after only one winter to feed at sea due to lack of food in Billy's Lake. These surveys could also show whether Dolly Varden leave in the spring or remain in the lake. A focused study of the Dolly Varden could also show their interactions with salmon in Billy's Lake.

Due to its proximity to Tatitlek, Billy's Hole would make an excellent study site for teaching local residents the skills needed to manage a subsistence and recreational fishery. In fact, Chugach Regional Resources Commission (CRRC), a co-principle investigator on this project, hired field technicians in 2003 and 2004 to participate in this study. These technicians were eager to learn and understand how to monitor escapements and assess salmon runs and were vital participants in all aspects of weir operations, data collection and information dissemination. Chugach Regional Resources Commission could have technicians in place at Billy's Hole in the summer collecting data on the fishery, learning skills needed for fisheries management while continuing to protect the resource for all users to enjoy.

This study met the objectives to enumerate salmon returns to Billy's Hole and can be compared to aerial surveys. However, due to the short 2-year duration of this study, run timing and escapements of coho and sockeye salmon cannot be predicted for future years. A further 4-year study would encompass a return of all brood years for sockeye and could allow for prediction of run timing and returns. Further study of angler use in Billy's Hole could help shape and direct management for this fishery, ensuring sustained yield for both subsistence and recreational users.

ACKNOWLEDGMENTS

Thanks to Brian Marston for graphing the depths of both Billy's and Gull lakes. Thanks to the weir crew including crew leader Gary Carpenter; Fish and Wildlife Technicians Adam Manor, Daniel Vlasoff, Michelle Vlasoff, Ken Selanoff, Brandon Totemoff and Ed Vlasoff. Special thanks to the Cordova AWL lab crew for processing the scales and the Cordova ADF&G front office crew for their help in maintaining radio contact with the camp.

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APPENDIX A. AERIAL SURVEYS OF BILLY'S HOLE

Appendix A1.-Historical aerial survey indices of salmon at Billy's Hole.

DATE	# FISH	YEAR
7/27/1963	200	1963
8/12/1963	700	
8/14/1964	2400	1964
7/8/1965	1000	1965
7/13/1966	1500	1966
7/24/1967	500	1967
7/26/1968	400	1968
8/2/1968	300	
7/8/1969	200	1969
7/29/1971	0	1971
8/11/1971	0	
7/8/1972	200	1972
7/17/1973	50	
9/12/1973	0	1973
8/4/1975	200	1975
8/11/1975	200	
7/15/1976	2600	1976
7/23/1976	2000	
8/2/1976	3600	
6/28/1977	0	1977
7/11/1977	100	
7/7/1978	0	1978
7/17/1978	700	
8/7/1978	800	
8/15/1978	500	
7/23/1979	100	1979
7/31/1979	600	
8/22/1979	90	
7/2/1980	0	1980
7/21/1980	0	
8/5/1980	0	
8/12/1980	0	
6/23/1981	0	1981
7/2/1981	0	
7/20/1981	0	
7/29/1981	0	
7/7/1982	600	1982
7/14/1982	1500	
7/21/1982	1500	
7/28/1982	3200	
8/3/1982	2500	
8/11/1982	1200	
8/20/1982	1000	
6/30/1983	5000	1983
7/12/1983	800	
7/20/1983	2500	
7/26/1983	4000	
8/2/1983	1500	
8/11/1983	600	
8/16/1983	500	
7/3/1984	4000	1984
7/17/1984	1500	
7/24/1984	900	
7/31/1984	900	
8/29/1984	200	
7/16/1985	300	1985
7/22/1985	100	
8/1/1985	1200	
8/5/1985	150	
6/26/1986	300	1986
7/3/1986	2000	
7/7/1986	2000	
7/14/1986	2450	
7/28/1986	4000	
8/5/1986	800	
8/4/1987	10	1987
7/27/1988	800	1988
8/1/1988	700	
8/8/1988	500	
8/15/1988	300	
8/23/1988	100	
7/10/1989	200	1989
7/17/1989	400	
7/25/1989	2500	
8/7/1989	600	
8/16/1989	80	
8/21/1989	50	
7/7/1990	450	1990
7/23/1990	1900	
7/26/1990	800	
7/31/1990	1900	
8/3/1990	825	
8/6/1990	1400	
8/13/1990	630	
8/15/1990	14	
8/21/1990	900	
8/30/1990	110	
9/4/1990	210	
9/11/1990	10	
7/12/1993	400	1993
7/2/1996	0	1996
7/10/1996	0	
7/18/1996	1200	
7/31/1996	600	
8/15/1996	100	
8/21/1996	0	
9/4/1996	200	
9/20/1996	200	
6/24/1997	25	1997
7/1/1997	0	
7/3/1997	600	
7/15/1997	20	
7/19/1997	500	
8/6/1997	50	
8/15/1997	0	
8/21/1997	0	
9/2/1997	50	
9/16/1997	30	
7/2/1998	150	1998
7/8/1998	0	
7/14/1998	0	
7/20/1998	50	
7/27/1998	600	
8/3/1998	450	
8/12/1998	200	
8/21/1998	0	
9/5/1998	20	
6/30/1998	0	
7/6/1999	30	1999
7/13/1999	500	
7/22/1999	1500	
7/29/1999	1800	
8/5/1999	2000	
8/13/1999	2100	
8/19/1999	600	
8/26/1999	220	
9/6/1999	0	
6/21/2000	0	2000
6/26/2000	0	
7/3/2000	0	
7/11/2000	50	
7/18/2000	50	
7/24/2000	60	
7/30/2000	700	
8/6/2000	450	
8/12/2000	450	
8/25/2000	200	
9/5/2000	0	
9/14/2000	8	
7/6/2003	75	2003
7/25/2003	400	
7/8/2003	550	
8/18/2003	200	
8/25/2003	300	

Source: From ADF&G Division of Commercial Fisheries historical aerial survey data. See Ashe et al. (2005) for explanation of methodology.

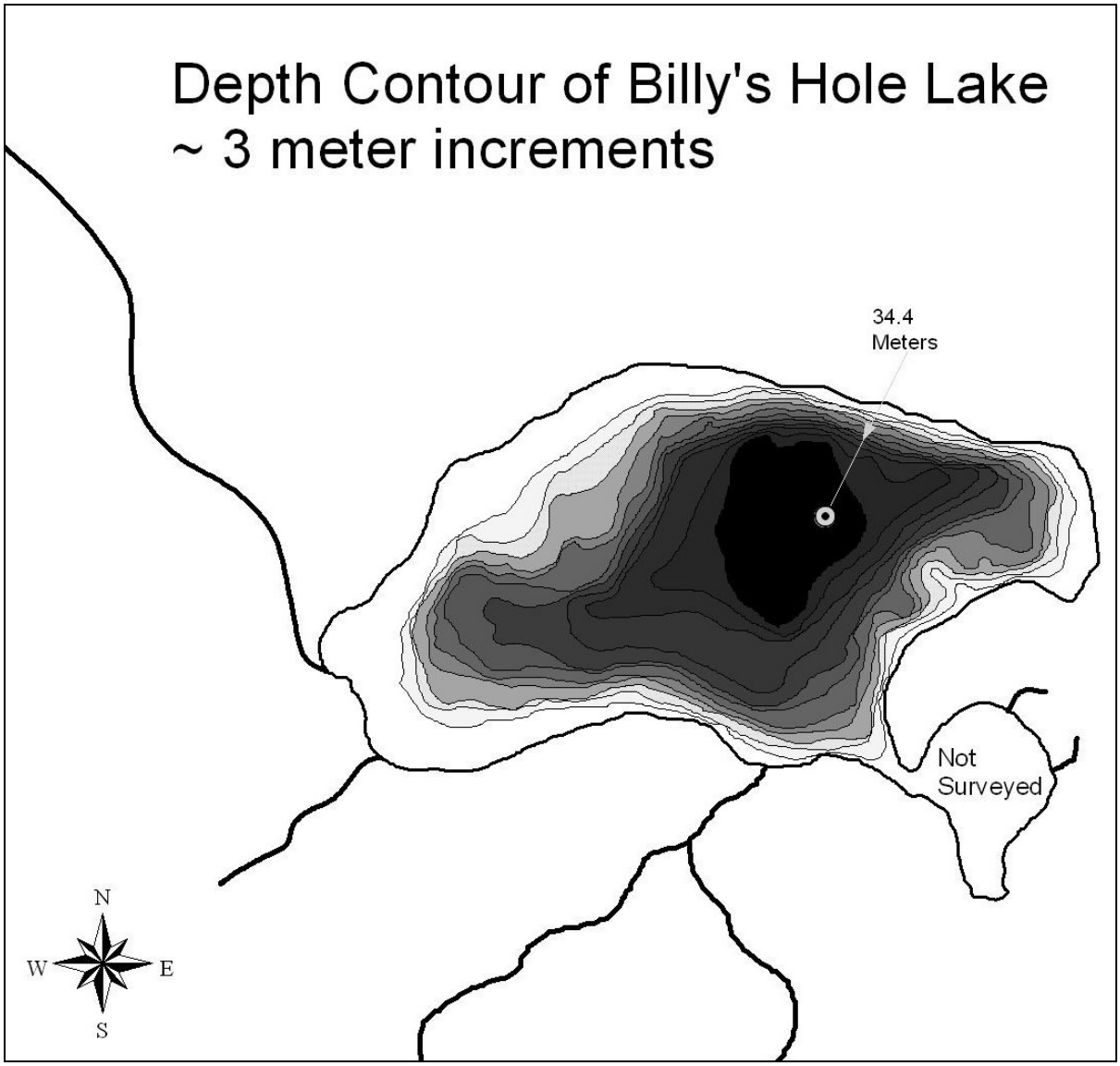
APPENDIX B. LIMNOLOGY AND BATHYMETRY OF BILLY'S LAKE AND GULL LAKE

Appendix B1.-Billy's Lake limnology data, July 2004.

POINT	LAT	LONG	DEPTH	WATER TEMP	pH	DOC[a]	CONDUCTIVITY
1	60 58 263	147 17 724	33.5m	4.5C	6.83		20.6
			34.3m	4.3C	5.9		19.4
			0m	16.1C	7.36		NA
2	60 58 117	147 27 825	1.52m	15.0C			
			3.05m	10.6C			
			4.57m	8.3C			
			6.10m	6.1C			
			7.01m	5.0C			
3	60 58 140	147 17 839	1.52m	14.44C			
			3.05m	11.11C			
			4.57m	8.3C			
			6.10m	6.1C			
			7.62m	5.0C			
			9.14m	3.33C			
			12.19m	2.78C			
4	60 58 146	147 18 010	1.52m	13.89C			
			3.05m	10.56C			
			4.57m	7.22C			
			6.10m	6.1C			
			7.62m	3.33C			
			9.14m	2.78C			
			10.67m	2.78C			
			12.19m	2.78C			
			15.24m	2.78C			
5	60 58 146	147 18 010	1.52m	12.78C			
			3.05m	9.44C			
			4.57m	8.3C			
			6.10m	6.67C			
			7.62m	5.56C			
			9.14m	4.44C			
			10.67m	2.78C			
			12.19m	2.78C			
			15.24m	2.78C			
6	60 58 259	147 18 013	1.52m	12.78C			
			3.05m	9.44C			
			4.57m	7.78C			
			6.10m	6.67C			
			7.62m	5.0C			
			9.14m	2.78C			
			10.67m	2.78C			
			12.19m	2.78C			
			13.72m	2.78C			
			15.24m	2.78C			
7	60 58 261	147 18 402	1.52m	12.78C			
			3.05m	9.44C			
			4.57m	8.89C			
			6.10m	7.78C			
			7.62m	5.56C			
			9.14m	3.89C			
			10.67m	3.33C			
			12.19m	3.33C			

[a] Dissolved oxygen content.

Appendix B2.-Billy's Lake bathymetry, 2004.

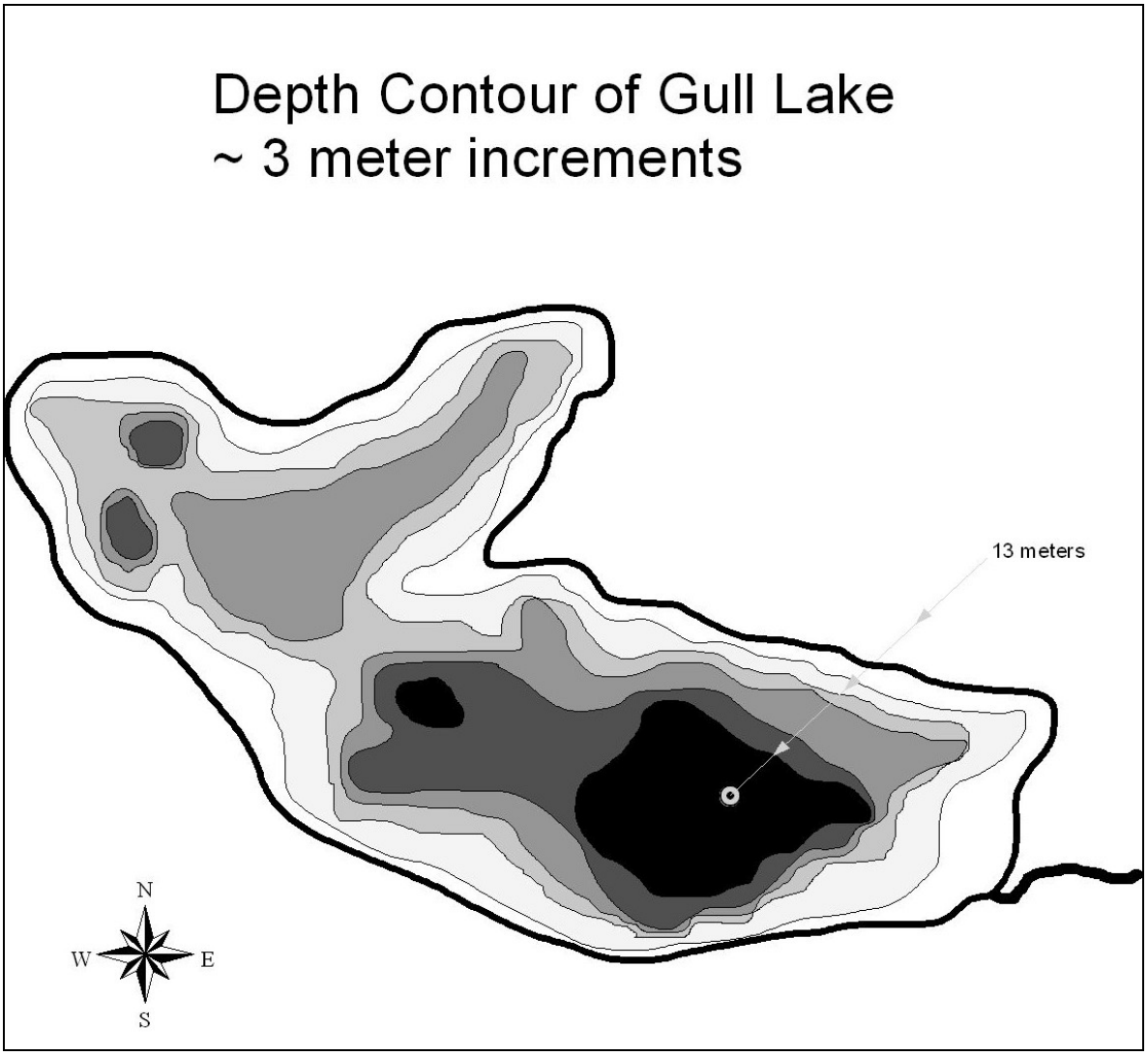


Appendix B3.-Limnological data for Gull Lake, July 2004.

Point	LAT	LONG	DEPTH (meters)	SURFACE TEMP	BOTTOM TEMP	DOC[a] READING	SECCHI (meters)
1	60 57 831	147 17 398	4.6m	16.1C	7.2C	10	4.6m
2	60 57 781	147 17 331	4.9m	16.1C	4.4C	11	5.6m
3	60 57 742	147 17 276	6.4m	16.1C	3.9C	10.1	7.8m
4	60 57 717	147 17 248	11.3m	15.0C	1.7C		
			11.0m			0	
5	60 57 717	147 17 194	10.4m	15.0C		0.9	7.8m
			7.8m		2.2C		
			10.2		2.2C		
6	60 57 738	147 17 183	9.5m	15.8C	2.2C		7.8m
			3.0m			13.2	
			6.1m			11.9	
			7.6m			10.4	
			9.1m			8.1	
			10.2m			1.1	
7	60 57 795	147 17 288	4.4m		7.2	10.9	7.8m
8	60 57 843	147 17 337	4.0m	16.1C	9.4C	10.4	7.8m

[a] Dissolved oxygen content.

Appendix B4.-Bathymetry of Gull Lake, 2004.



APPENDIX C. ADDITIONAL DATA

Appendix C1.-Summary of incidental angler interviews at Billy's Hole, 2004.

Date	Sub or Rec	# Anglers	Resident Non-Res	Hrs fished	Effort in hrs	Gear used	Species	# Kept	# Released
6/12/2004	Rec	3	UNK	1.5	4.5	Rod/Reel		0	0
6/26/2004	Rec	2	UNK	0.25	0.5	Rod/Reel		0	0
6/30/2004	Rec	3	UNK	0.75	2.25	Rod/Reel		0	0
7/1/2004	Rec	2	UNK	14	28	Rod/Reel	sockeye	4	UNK
							pink	UNK	1
							chum	UNK	1
							dolly v	1	2
7/1/2004	Rec	3	UNK			Rod/Reel		0	0
7/3/2004	Rec	2	UNK			Rod/Reel	halibut	3	0
7/6/2004	Rec	3	UNK	1	3	Rod/Reel		0	0
							chum	1	6
							dolly v	2	3
7/9/2004	Sub	2	2Res			Gillnet	sockeye	30	0
7/16/2004	Rec	3	UNK	18	54	Rod/Reel		0	0
7/17/2004	Rec	3	UNK	6	18	Rod/Reel		0	0
7/24/2004	Rec			2		Rod/Reel		0	0
7/29/2004	Rec	5	UNK	1	5	Rod/Reel		0	0
8/2/2004	Rec	5	UNK	1.5	7.5	Rod/Reel		0	0
8/4/2004	Rec	1	UNK	2	2	Rod/Reel	sockeye	1	0
							pink	0	1
							coho	0	1
8/9/2004	Rec	1	UNK	UNK	UNK	Rod/Reel		0	0
8/21/2004	Sub	2	2Res	0.5	1	Rod/Reel		UNK	UNK
TOTAL		40		48.5	125.8				